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THERMAL IMAGING APPLICATIONS IN URBAN DEER CONTROL

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Abstract: Control of burgeoning populations of white-tailed deer (*Odocoileus virginianus)* is a challenging endeavor under the best of circumstances. The challenge is further complicated when control programs are attempted within an urban or suburban area. Wildlife managers often consider management techniques and equipment which have a proven track record. New challenges require new and innovative techniques. The deer management program in Fairfax County, Virginia has employed thermal imaging technology in a variety of ways to better address these unique challenges. In addition to the more commonly used aircraft-mounted FLIR (forward looking infrared), this program utilizes vehicle-mounted and hand-held thermal imaging devices. Thermal imaging is used in determining herd densities, ensuring that control areas are free of humans, locating deer, assessing target attributes and recovering culled deer. These devices bring a higher level of safety, efficiency and efficacy to control programs operating within these difficult environs.

Key words: Fairfax County, *Odocoileus virginianus*, thermal imaging, urban deer control

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INTRODUCTION

With white-tailed deer (*Odocoileus virginianus*) herds at unprecedented levels through much of the eastern United States, many suburban and urban communities have sought some workable solution to the many associated problems. Fairfax County, Virginia adopted and integrated an approach which has included direct herd reduction through managed public hunts and sharpshooting.

The sharpshooting program is conducted under the Fairfax County Police Department (FCPD) and utilizes trained police snipers from the Department's Special Weapons and Tactics (SWAT) unit. FCPD has a variety of specialized equipment which lends itself well to an urban deer control program. Some of this specialized equipment will be described as will their program-related applications.

Thermal imaging equipment in several configurations has played a key roll in the success of this program. Safety and efficiency are key elements of any such program and thermal imaging devices help ensure these deliverables.

SITE DESCRIPTION

Fairfax County, Virginia encompasses 103,341 hectares (399 square miles) and lies to the southwest of Washington, D.C. With scattered urban centers of its own, Fairfax County is home to over one million residents. There are seven states with populations less than that of Fairfax County.

A population of this size requires a great deal of infrastructure. There are more than 7,500 lane miles of roads (1995 FCPD figures) and over 800,000 registered automobiles in the county. Fairfax County's population has increased 11% since 1996;

however, the neighboring counties of Prince William and Loudon have shown population increases of 23% and 73%, respectively for the same period. Many commuters from these adjacent counties add to the traffic load of Fairfax County. The Virginia Department of Transportation (VDOT) predicts a 5% increase in traffic volume each year due to population growth in and around Fairfax County.

Parallel growth has also occurred in the deer population. Annual deer-vehicle collisions (DVCs) have ranged between 3,000 and 8,000 for the last decade. This has kept the issue on the public agenda and has made the public aware of the problem. Whether a driver has personally been involved in a DVC or not, most if not all drivers have witnessed DVCs or seen dead deer on the shoulder of the roads. This awareness has contributed to the high level of public support for herd control efforts. Additionally, many citizens are aware of the damage that deer have inflicted on landscape and natural vegetation. A survey of Fairfax County residents found that 73.6% would support a direct reduction of the deer herd if deer damage resulted in a decrease in biodiversity within public parks (NCR 2001).

TRADITIONAL SURVEY METHODS

Various methods of surveying deer herds have been employed and the relative merits of each have been and will be debated by their respective supporters. The use of spotlights (Ford 1987, Begier 1996, Belant and Seamans 2000, Focardi et al. 2001, Hodnett 2003) infrared-triggered cameras (Jacobson et al. 1997, Koerth et al. 1997), faecal pellet counts (Prachar et al. 1987, Campbell et al 2004, Smart et al. 2004), track counts (Prachar et al. 1987), mark resight (Gavin et al. 1984, Storm et al. 1992) and change-in ration (Conner et al. 1986) are but a few of many techniques available.

Distance sampling surveys can be heavily biased. A field simulated study found that the width of dense habitat was overestimated while the width of defoliated habitat was underestimated. These errors in estimations led to deer densities being overestimated in dense habitat and underestimated in defoliated habitats (Whipple et al. 1994). In some areas, deer avoid roads at night (Ward et al. 2004). This reaction can be in response to disturbance or illegal poaching. In Fairfax County, this behavior is nearly always observed following night time culling activities.

Spotlight counts, like all techniques have limitations. Conventional spotlight counts utilize one driver and two observers. The observers are positioned in the bed of a pick-up truck and each operates a handheld spotlight and conducts a count (Ford 1987).

Detection of distant deer may rely upon eye shine alone. Bedded deer can present a problem in that up to 50% of these deer can go undetected (Begier 1996). Counting in a forest or brushy habitat limits the range of the light as much of it gets reflected back at the observer by foliage. This limitation can be lessened by using a more sophisticated light. Some special military and law enforcement teams and many fire departments utilize a MaxaBeam™ Searchlight. This is a 6 million candle power hand-held spotlight with a focusable beam. The light beam can be adjusted from a 40° wide angle to a pinpoint by use of a power-assisted switch. With its 75 watt Xenon lamp, this light can define a clear route through thick brush which a sharpshooter could utilize. Splash back light is minimal with the MaxaBeam™ focused to a narrow beam (Hodnett 2003). MaxaBeam ™ spotlights are often used in the movie and television industry because the narrow beam of light, with a little smoke

added, is much more easily captured on film.

If the area to be surveyed is extensive or if time is a factor, aerial surveys may be preferable. Aerial surveys have been used in a multitude of forms and variations for many years (Beasom et al. 1986, Shupe and Beasom 1987, Koerth et al. 1997, and Dunn et al. 2002). Both fixed and rotary winged aircraft have been used and each has its own advantages and disadvantages. Double count surveys, where two observers are separated but positioned on the same side of the aircraft, afford a higher degree of accuracy than single observer counts (Potvin et al. 1992). With any aerial survey, two variables: speed and altitude can have a significant effect on the quality of data produced. One such limitation is the ability to properly discriminate spike bucks for the purpose of determining sex rations (Shupe and Beasom 1987, Leon et al. 1987). Sightings of marked fawns from helicopter surveys have been shown to be lower than the overall proportion of fawns in a marked population (Sullivan et al. 1990). Deer in thick cover may not be detected in aerial visual or even FLIR (forward looking infrared) assisted counts. Infrared counts can be confounded by thermal distractions such as large rocks or standing water that may be mistaken for deer (DeNicola et al. 2000). Such distractions are further complicated in urban or suburban areas. Lights, manhole covers, storm sewer inlets, electrical transformers, telephone pedestals, metal signs and large dogs all compete for the FLIR operator's attention.

Aerial counts, utilizing visual or FLIR equipment, conducted with the advantage of a complete ground cover of snow can be more difficult than expected. These conditions may encourage deer to spend more time in dense cover. The presence of a dense tree or understory canopy can affect the relative accuracy of both aerial techniques (DeNicola et al. 2000).

All aerial counts share one major disadvantage – cost. This single factor can eliminate this technique in many situations. The expense of these techniques often drives the application design. In south Texas, it was shown that more replicates of a smaller sample size made the survey more reliable and cost effective (Beasom et al. 1986). If extensive tracts are to be surveyed or if time is a critical factor, aerial counts may be the most cost effective choice (Trenkel et al. 1997).

THERMAL IMAGING

Thermal imagers (TI) have been used in military, law enforcement, search and rescue as well as wildlife management applications. While the technology has been around for decades, thermal imaging equipment tended to be large and expensive until Raytheon ™ brought TI to the civilian commercial market. Today there are TI hand-held units which literally fit in the palm of your hand.

Thermal images, also know as infrared (IR) images are visible representations of electromagnetic radiation in the infrared (IR) band (thermal radiation: 3-14 microns). In contrast with radiation in the visible band (0.4-0.7 microns), which is immediately reflected by terrestrial objects, radiation in the IR band is gradually accumulated and emitted. Thus, thermal radiation represents the "memory" of heat that has been accumulated during the day and can be used to extend human vision into the night (Brickner and Foyle 1995).

Most thermal cameras are built on the same general model. Claude C. Caillas of The Robotics Institute at Carnegie Mellon University listed standard TI components (Cailas 1990):

- A window protecting the optical system and allowing infrared light to enter.
- An optical system for focusing and correcting the chromatical and spherical aberrations.
- A scanning system consisting of rotating mirrors allows the detector to see the entire scene by sequentially analyzing the image.
- A system of infrared filters for selecting the desired wavelength band.
- A sensor that transforms the infrared thermal energy into an electrical signal.
- An amplifier for the electrical signal

The Fairfax County Deer Management Program has utilized four different types of TI equipment. The Fairfax County Police Department operates two Bell™ Long Ranger 407 helicopters as air support and also as medical evacuation aircraft. These helicopters are currently fitted with the Wescam™ DS200 Video Imaging System. These units are combination TV cameras/thermal imager cameras. The TI function operates in the 3-5 micron spectrum. The camera has a rotation capability of 360°azimuth and can elevate from +90°to -120°.

Two Raytheon Infrared™ ProtectIR 4000M thermal imaging systems are used as vehicle-mounted units. These units can pan 360° and can elevate from -20° to +110°. They operate in the 7-14 micron spectrum. One of these units has been mounted on a custom base which fits into a 2" x 2" trailer hitch receiver. Receivers have been welded onto a brush guard for low viewing (below typical browselines) and onto the frame of an over cab shooting platform. This higher position is more suitable for viewing open field areas. These TI units are primarily used to conduct deer herd surveys before any control operations begin. Once control operations commence, these units are used to locate deer and position the shooting vehicle for a safe shot.

A small monitor is mounted on the dashboard of the shooting vehicle. This monitor can be turned for viewing by the driver, the passenger or both. Most of the culling operations in the Fairfax County Program are conducted without the vehicle headlights on. This is done to avoid attracting attention but also to avoid warning other deer in the vicinity. On dark nights, the light emitted by the monitor can interfere with the driver's ability to see through the windshield. It also serves as a light source which inadvertently illuminates the occupants of the vehicle. This should be avoided for the same reasons that the headlights are turned off. To address this problem, layers of red cellophane have been cut to fit the monitor screen. This eliminates both problems and actually seems to increase the contrast of images on the monitor.

The most useful TI unit in the program is the Raytheon Thermal-Eye™ 250D Digital. This hand-held unit is light weight (approximately 3 pounds) and is simple to operate. It operates in the 7 to 14 micron spectrum and is rated to detect a person at 2400 feet. Another hand-held TI that has been used in the program is the Raytheon Thermal-Eye™ X100xp. This is a very small unit and also operates in the 7-14 micron spectrum but has a detection range of less than half that of the 250D. The visual resolution also falls short when compared to the 250D. Therefore, the X110xp has not proven to be a suitable choice for deer detection.

The 250D is typically used by a spotter standing in the bed of the shooting truck. He can cover one side of the road while the vehicle-mounted unit covers the

other. The most valuable use for this unit is in the recovery of culled deer. Deer that fall in tall grass or other thick vegetative cover can sometimes be difficult to locate with conventional light sources. In some cases, a large number of deer might be engaged over an extended period of time. This can cause confusion as to how many deer are actually down. The use of a hand-held TI will help ensure the recovery of all deer taken.

The use of ground–based TI units offers considerable advantages over many other survey techniques. TI equipment has been found to be a more efficient technique for locating fawns than foot searches, female behavior cues, spotlighting or vaginal transmitter implants (Smith et al. 2004). Over twice as many deer were detected in an Arkansas study comparing ground-based TI counts (243 deer, 19 counts) and spotlight counts (105 deer, 19 counts) (Tappe et al. 2003). TI equipment enables the user to view deer at a greater distance than typical spotlights would allow.

Another significant advantage that TI technology provides is the ability to accurately record data as it is collected. The data can be digitally recorded, enhanced and intensively reviewed and analyzed with computer software to detect animals which might have been missed by a single observer (Dunn et al 2002). Capturing this data digitally also allows multiple reviews by multiple reviewers. The data can then be archived for possible use in future unrelated studies.

Some studies have suggested that only TI should be used to survey certain species. Such is the case with wild boar (*Sus scrofa)* which lack a well-reflecting tapetum lucidum in their eyes (Focardi et al. 2001). Larger sample sizes are almost always produced with the use of TI. However, it has been suggested that distance sampling using TI (as well as faecal standing crop and faecal accumulation rate techniques) performed poorly in detecting population change (Smart et al. 2004).

TI can have other complications which may be terrain related or species related. Species with dense hair or feathers may be so well insulated that only small amounts of thermal radiation are being emitted. The dense hair on the cape of elk (*Cervus canadensis*) can cause the thermal image to appear broken between the head and torso (Dunn et al. 2002). During the winter, hollow hair of cervids can be nearly the same temperature as the ambient temperature thus making a large portion of their body more difficult to detect (Graves et al. 1972). Wild turkeys (*Meleagris gallopavo*), may appear as faint images but their naked heads and necks produce strong images. Thermal images of polar bears (*Ursus maritimus*) demonstrate that heat loss in this species is efficiently restricted to the eyes, nostrils and mouth.

UNIQUE URBAN CHALLENGES

Deer control programs often present new challenges to the wildlife manager. These challenges are simply amplified in a suburban or urban setting. These venues deliver new and sometimes daunting challenges bundled with the more mundane challenges inherent in such programs.

The Fairfax County Deer Management Program conducts herd reduction operations at night in parks and on other public properties. Nearby residents are notified by mail that the operations will occur at night but specific dates are not provided. Thermal imagers, night vision scopes and suppressed rifles are utilized in order to avoid attracting unnecessary attention. These methods also reduce the disturbance to other deer that may be nearby.

In the Fairfax County Program, infrared triggered cameras are used to census deer (Jacobson et al. 1997) prior to a

park being included in any control operations. Once culling operations have begun in a particular park, periodic census counts may be conducted to measure the progress toward attaining herd density goals. Spotlight counts are not suitable for this purpose since local deer will have been sensitized to spotlights and perhaps even vehicles. A TI enables these counts to be conducted in total darkness with the least possible disturbance to deer.

Avoiding the use of light as much as possible is a good rule of thumb since urban control operations may require a more covert approach to avoid unnecessary complications. The use of spotlights to conduct surveys might attract curious visitors who could later compromise safety. Light sources in unusual locations can distract drivers on nearby highways creating an additional safety concern (Hodnett 2003). Spotlights can create a visual intrusion to both deer and people. Thermal imaging can be used to survey deer unobtrusively and can be used in places where a spotlight would be unacceptable (Belant and Seamans 2000).

Many parks in Fairfax County still exhibit a distinct browseline as deer have depleted much of the natural food sources. Roadways within parks often are edged by areas of turf grass and many parks contain grass covered athletic fields. These areas tend to become an important food source for local deer herds. Since most of the natural browse in the forested areas has been depleted, deer are drawn to these grassy areas. This can lead to overestimations of deer populations when spotlight counts are utilized under such conditions.

Fairfax County includes properties such as airports, military installations and government buildings which may have air space restrictions. These restrictions may be permanent or may be associated with threat level designations or even high use time intervals. This may limit the use of the helicopter-mounted FLIR and make the vehicle-mounted or the hand-held versions more appropriate. Another disadvantage of using police helicopters is that they may be understandably diverted from a wildlife mission to a higher priority call.

Urban areas also may have citizens who are hypersensitive to any unusual activity that they may see. In recent years, the public has been encouraged to notify authorities of any such activities. This, in and of itself, is reason enough to utilize TI wherever possible.

Urban areas may experience some tragic event which places everyone on higher alert. In 2002, John Allen Muhammad and Lee Boyd Malvo terrorized the Washington D. C. metropolitan area (including Fairfax County) by conducting random sniper attacks upon innocent citizens. Obviously this brought the deer control program to a temporary halt. The police were inundated with calls from citizens who had seen anything that they deemed unusual. This was not a time for even the most covert activities in parks. Wearing camouflage clothing, using a spotlight or even driving a vehicle in a park at night was out of the question.

The additional challenges of urban deer control require additional management techniques. The use of TI technology is ideal for conducting nonintrusive surveys which will typically also produce larger sample sizes. For culling operations, TI technology will provide faster target location and confirmation. Recovery of culled deer is especially important in urban programs. Their most important use, however, is in ensuring public safety by making certain that operational areas are free of unauthorized people.

With a TI, critical habitats for roosting birds can be identified by simply scanning thickets at night. Nocturnal

animals can be observed without introducing any disturbance bias. Nest boxes can be monitored without approaching the box. Intruding wildlife can be located in home attics. Small animals can be easily located in heavy cover. The list can go on limited only by one's imagination. For these reasons and for many yet to be realized, thermal imaging devices should become a primary tool for the urban wildlife manager.

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